

# Technical News Bulletin

of the  
National Bureau of Standards

★ Issued Monthly ★

Washington

FEBRUARY 1935

Number 214

## CONTENTS

Directional radio as an aid to marine navigation.  
The national primary standard of radio frequency.  
Stresses in a propeller blade.  
Infrared radiation from an Otto cycle engine.  
Moisture relations of aircraft fabrics.  
Psychrometric charts for high and low pressures.  
Impact and static tensile properties of bolts.  
Influence of oxide films on the wear of steel.  
Oxygen and nitrogen in antimony crystals.  
Russian visitor studies "gases in metals."  
Traffic signals.  
Relation between composition and properties of glasses.

Lightning and the Washington Monument.  
Hinges for reinforced-concrete structures.  
Tension tests of firebrick.  
Calibration of Wagner turbidimeter.  
Standards for gas service.  
Specific volume of rubber-sulphur compounds.  
Deterioration of vegetable-tanned leather by sulphuric acid.  
Combining weight of collagen.  
New and revised publications issued during January 1935.  
Reports of National Hydraulic Laboratory.  
Recent Bureau articles appearing in outside publications.

### DIRECTIONAL RADIO AS AN AID TO MARINE NAVIGATION

There are a number of applications of radio which make for safety in marine navigation. These include intercommunication among ships, the broadcasting of information such as weather reports, time signals, iceberg warnings, distress signals, and direction determination. The principal system for direction determination is the radio direction finder, used in conjunction with radiobeacons as installed on many lightships and lighthouses. The radiobeacon broadcasts a coded signal at timed intervals, while the direction finder, when used aboard ships, indicates the direction to the source of the signal, and enables the navigator to get an azimuth bearing with respect to the beacon. With cross bearings on two or more radiobeacons, or point bearings on a single radiobeacon, the ship's position may be obtained.

This system was developed in co-operative experiments by the U. S. Lighthouse Service and the Bureau in 1920. Radiobeacons were installed on Ambrose Channel and Fire Island lightships and at Sea Girt (New Jersey)

lighthouse, and a radio direction finder was installed on the lighthouse tender *Tulip*. These early experiments showed the great value of the system. Up to the present time the Lighthouse Service has installed approximately 106 radio beacons on our coasts, and there are a considerable number on foreign coasts. There are over 4,000 radio direction finders installed on ships throughout the world. Many instances are on record where the radio direction finder has been the means of locating a ship in distress and has thus made possible the saving of many lives.

There are three general classes of radiobeacons, known as A, B, and C. They differ principally in their power rating. The class A radiobeacon is rated at 200 watts or over, the class B from 100 to 200 watts, and the class C below 100 watts. The class A beacon is used for long-range work, such as the one installed on Nantucket Shoals Lightship. This is the first beacon to be picked up by vessels approaching New York from the east. The class B beacon is the more common type and is used on lightships such as the Am-

brose Channel Lightship, as well as on outside coast stations. The class C beacon is usually used on inland waterways as, for instance, Long Island Sound. The radiobeacon on Stratford Shoals Lighthouse is an example of this type of beacon. Neighboring beacons usually operate in groups of three. The stations of each group operate on the same radio frequency, and each radiobeacon in the group is timed so that one transmits for one minute, a second for the second minute, and the third for the third minute. Each has a different coded characteristic for identification. Charts issued for the use of mariners by the U. S. Lighthouse Service give full details as to each radiobeacon, its location, class, characteristic signal, etc.

Some of the radiobeacon installations operate simultaneously with a sound signal through the air, so that a navigator may determine distance as well as direction. The difference in time between the arrival of the radiobeacon signal and the sound signal makes possible this distance determination. One radiobeacon is similarly synchronized with a submarine oscillator.

Rough distance determination may also be made for the purpose of avoiding collision with a lightship by steering so as to pass to one side of it. Successive radio bearings are taken, and these, with the intervening distance run, are used to ascertain the distance off from time to time.

Most of the direction finders in use on ships of the United States are of the simple rotating-coil type, with which a bearing is taken by listening for the point of minimum signal from the beacon, as the coil is rotated. A somewhat more complex type of direction finder recently developed at the Bureau is one in which the bearing indication is given by a zero-center pointer-type instrument. As the direction-finder coil is rotated the correct bearing is obtained when the pointer reads zero. This was developed primarily for airplanes, but would be useful also in marine service.

Tests have been made recently, with some degree of success, of a warning radiobeacon. This emits a low-power signal, with a continuous high-low or warble note, and is intended to have an average range of about ten miles. The tests indicate the probable value of such signal on certain lightships, both to guide vessels and to protect the lightships.

Tests made on the Great Lakes by the Lighthouse Service have indicated

the feasibility of the use by navigators of low-power radiobeacons on shipboard to obtain radio bearings on neighboring ships and thus avoid collisions.

Tests have been made in England of a system by which a ship can determine its position without the use of a direction finder. A transmitting coil antenna at the shore station is rotated at a known speed and a characteristic nondirectional signal is sent when the minimum signal is being sent north. By the use of a stop watch and the ship's radio receiver a pilot is able to determine his azimuth position with respect to this beacon.

The use of ultra-high radio frequencies is developing rapidly. It may soon be possible to direct a radio beam (approximately one-half meter in wave length) from the upper structure of a ship and orient it forward in such a fashion that a highly directive receiver, underneath the transmitter and oriented to receive forward, will receive the signal only when some reflecting object exists in front of the ship.

#### NATIONAL PRIMARY STANDARD OF RADIO FREQUENCY

The national primary standard of radio frequency, described in the February number of the Journal of Research (RP59), consists of two independent groups of piezo oscillators using specially prepared quartz plates operating under controlled conditions as regards temperature, pressure, humidity, and voltage. The first group, known as section I, was a commercial development and consists of four piezo oscillators with frequencies of 100 kc/s. Section II, which was constructed at the Bureau, consists of two piezo oscillators, one having a fundamental frequency of 100 kc/s and the other 200 kc/s. An output of 100 kc/s is obtained by means of a submultiple generator. A separate voltage-supply system is provided for each section. Rectifiers furnish filament and plate voltages, which are filtered and held constant by an automatically adjusted battery-charging system.

The absolute frequency of one of the units of each section is checked daily against the Arlington time signals by a synchronous-motor clock driven by the 100th submultiple of the frequency of the controlling unit. The daily measurements provide a check on the frequency variations of the standard over an extended period. Frequency variations over short intervals are shown by an automatic recorder of the frequency difference between one of the units of

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section I and each of the other five units.

Submultiple frequencies from the primary standard are used in several laboratories of the Bureau. A standard frequency of 5,000 kc/s is transmitted four hours a week and is extensively used by radio manufacturers, radio transmitting stations, and testing laboratories throughout the United States in the calibration of standards of frequency. These transmissions are maintained in agreement with the primary standard.

Curves are presented for the two units measured in terms of the Arlington time signals. These curves show a small increase in frequency with time. The unit with the smaller change showed a frequency drift of about one part in 10 million per month.

#### STRESSES IN A PROPELLER BLADE

RP764 in the February number of the Journal of Research describes part of an investigation on propeller vibrations that is being carried out at the Bureau with the hope of learning more about propeller failures in flight. These failures, while few in number compared to the number of propellers in service, usually have serious consequences. The failure of a propeller may result in wrecking the plane, and sometimes in loss of life.

Service failures have, in general, the appearance of fatigue fractures, thus pointing to high alternating stresses as the source, such as would be set up during resonant vibrations. In the present paper the stresses considered are those set up in nonrotating propeller blades that are caused to vibrate by an alternating torque of controllable frequency and amplitude applied to the propeller shaft. A method is described for measuring the amplitude of the vibration at the tip of the propeller. Two pronounced resonant vibrations were found in a duralumin blade of typical design, one at around 35 cycles per second, at which the blade was bending back and forth like a cantilever beam, and another at about 130 cycles per second, in which the motion of the blade had a node not far from the tip.

The stresses set up in the blade during these vibrations were determined from strain measurements made with a Tuckerman optical strain gage. The maximum stresses for the first type of vibration, at 35 cycles per second, occurred at about the mid-blade position,

and the maximum stresses for the second type of vibration (130 cycles per second) occurred about a quarter blade length from the tip.

The stress measurements were checked by a theoretical analysis proceeding from the differential equation of motion of a vibrating beam of variable section. Measured and calculated stresses were found to agree within a few percent.

The theory was used also to study the effect of the condition of restraint at the hub on the motion of the blade. It was shown that the restraint at the hub had little effect on stress distribution, but considerable effect on frequency.

A final check on the method for measuring stresses was obtained from artificial fatigue failures for eight blades vibrating with their fundamental frequency. These blades failed at a section in the mid-portion where the stresses were within a few percent of the maximum stresses measured.

#### INFRARED RADIATION FROM AN OTTO CYCLE ENGINE

In Technical News Bulletin No. 213 (January 1935) it was stated that parts II and III of the paper on infrared radiation from an Otto cycle engine would be published in a forthcoming number of Industrial and Engineering Chemistry. It has now been decided not to publish this material at this time.

#### MOISTURE RELATIONS OF AIRCRAFT FABRICS

Atmospheric humidity exercises an important influence on the static lift of airships because of the very hygroscopic nature of some of the fabrics which are used in their construction. It was the purpose of this investigation, which was reported in the January number of the Journal of Research as RP758, to determine the amount of water which the aircraft will be required to support under varying atmospheric conditions.

Two experimental methods for measuring the amount and rate of absorption of moisture were used. In the first the sample is suspended in a stoppered bottle over a salt solution or water according to the relative humidity desired. In the second method air at the desired relative humidity is forced over the sample suspended in a closed bottle. The results obtained by the two methods for gas-cell fabrics are practically identical, indicating that the rate of diffusion of water molecules to

the neighborhood of the sample merely suspended over the aqueous solution exceeds or is at least equal to the rate of absorption of the water vapor. The static method is preferred for its simplicity, reliability, and the compactness of the equipment required.

Aircraft fabrics doped with cellulose nitrate, such as are used on the wings and fuselage of an airplane, were found to absorb only small amounts of water at high humidities; the gain in weight in a saturated atmosphere was less than 12 percent of the weight of the fabric in the standard conditioning environment, 21° C. and 65 percent relative humidity. Aircraft fabric doped with cellulose acetate, commonly used for the outer cover of airships, behaves similarly to the fabric coated with cellulose-nitrate dope at relative humidities as high as 97 percent. At 100 percent relative humidity the cellulose-acetate product is more hygroscopic and gains about 20 percent moisture in 1 week and 40 to 55 percent over a period of many weeks.

The gas-cell fabric studied, which consisted of balloon cloth coated with gelatin-latex plasticized with polyglycerol and is used in the construction of the gas cells which hold the helium in the airship, is exceedingly hygroscopic and on exposure to a saturated atmosphere is capable of taking up in seven days water equivalent to approximately 50 percent of its weight and in four weeks' time it approximately doubles its weight. The rate of absorption is retarded considerably by paraffin, which is always applied to the gas-cell fabric in service; the increase in weight due to paraffin, however, largely offsets the decreased weight of water. Thus, by the application of 14 percent by weight of paraffin to the lightweight gas-cell fabric, the moisture absorption is decreased to 30 percent in seven days and 60 percent in four weeks at 100 percent relative humidity. Study of the desorption of moisture from the unparaffined and paraffined gas-cell fabrics shows that the unparaffined material loses the absorbed moisture comparatively rapidly, whereas the paraffined material requires approximately the same period for the desorption as for the absorption of moisture. The gas-cell fabrics have been found to be very susceptible to attack by mold. It is desirable that a fungicide be added to these fabrics with the gelatin-latex coating in order to prevent the deterioration of the finished product by mold action.

#### PSYCHROMETRIC CHARTS FOR HIGH AND LOW PRESSURES

A series of charts has been developed at the Bureau which facilitates the determination of humidity from the readings of dry- and wet-bulb thermometers. This determination is becoming of great importance with the rapidly increasing application of air conditioning to industrial processes.

Humidity charts and tables heretofore used have been strictly correct only at one air pressure, if at all. The present charts are equally correct at air pressures encountered in stratosphere flights or in the deepest mines. While the pressure graduations on the charts run from that for 50,000 feet altitude to 10 times normal atmospheric pressure, the charts can be used at any other pressure by either of two expedients.

Not only can the charts be used to evaluate relative humidity or pressure of water vapor from psychrometric data; they can be used also to determine the dewpoint, the saturation pressure of water, how to obtain a desired relative humidity by heating or cooling a given atmosphere, and the precision required in psychrometric measurements to obtain a desired precision in the result.

Four charts comprise this series, two being for use each with Fahrenheit and with centigrade thermometers. By thus dividing the temperature range, part being covered on each of two charts, interpolation can be practically eliminated for ordinary work. This makes the use of the charts simpler and more rapid. These charts have been published as Miscellaneous Publication M146, obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents a copy.

#### IMPACT AND STATIC TENSILE PROPERTIES OF BOLTS

Bolts are used in machines and structures to fasten together certain parts which cannot readily be made of one piece, or which must be removed for adjustment, cleaning, or repairs. In many cases these fastenings are subjected in service to static and to impact tensile loads. In designing a structure the engineer must know not only the greatest load which a bolt will sustain without failing, but also the work (force times distance) required to rupture the bolt. This is important because, under unusual circumstances, the bolted structure may be subjected

either to steady or to impact loads greater than the working loads for which the structure was designed.

The resistance to static loads depends upon the tensile strength of the bolt with nut. The resistance to impact loads, however, depends upon the work required to rupture the bolt under suddenly applied loads. This "impact work" depends not only upon the tensile strength but upon other factors, one of the most important of which is the amount of stretch between the head of the bolt and the nut when rupture occurs.

Many investigations have shown that for metals under either tensile or transverse loading the work required to rupture the specimen under loads applied slowly (the "static work") is not equal to the work required to rupture it under loads applied suddenly (the "impact work").

An investigation was made some time ago at the Bureau to determine the properties of bolts under impact tensile loading and also under static tensile loading. The results are given in RP763 in the February number of the Journal of Research. Three hundred and sixty specimens were tested, representing all the possible combinations of five different materials (chromium-nickel steel, cold-rolled steel, monel metal, bronze, and brass); four different bolt diameters ( $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{3}{8}$ , and  $\frac{1}{2}$  inch); and three different forms of screw threads (American National coarse, American National fine, and Dardelet). These threads are often used for bolts, the U. S. Standard threads being almost the same as the American National coarse threads and the SAE threads practically the same as the American National fine threads.

The bolts of different diameters were geometrically similar, the length between the head and the bearing face of the nut being five times the diameter, and the thread extending inward from the face of the nut for one diameter. In all cases the impact works for bolts having American National coarse threads were less than the impact works for bolts of the same size and material having American National fine threads. Except for the brass bolts and those cold-rolled steel bolts which showed brittle failures, the impact works for bolts having American National fine threads were approximately the same as the impact works for bolts of the same size and material having Dardelet threads. In all cases

the impact works for bolts having Dardelet threads were much greater than the impact works for bolts of the same size and material having American National coarse threads.

The relations of the static works and the maximum static loads were similar to those for the impact works.

For bolts of the same size and having the same threads the bolt efficiencies were approximately the same for all of the materials.

The results of this investigation will make it possible for engineers to use screw threads which will give the best results in service, and the public will benefit through increased safety and efficiency of machines and structures.

#### INFLUENCE OF OXIDE FILMS ON THE WEAR OF STEEL

A few months ago the Bureau published the results of a study of the influence of oxide films on the wear of several plain carbon steels (J. Research NBS 13, 267 (August 1934) RP708). It was shown that under given conditions of load and slip in metal-to-metal wear, the wear of carbon steels having a wide range of hardness was not very severe when tested in air and that a smooth filmed surface resulted. However, in a hydrogen atmosphere, but otherwise under the same conditions, carbon steels with higher hardness numbers (about 56 Rockwell C) wore relatively little, accompanied by the formation of very thin films, whereas steels of lower hardness suffered excessive wear and the worn surface was rough and showed no visible film.

The wear of stainless steels is now being studied. Preliminary results show that there is a similar change in character of wear when tests are made in hydrogen. A very noticeable difference, however, has been observed with a ball-bearing type stainless steel when tested in air. Under these conditions the stainless steel shows a transition from heavy wear with a rough film-free surface to relatively little wear with a smooth filmed surface as the hardness of the stainless steel increases from 45 Rockwell C to 62 Rockwell C (approximately). Apparently in the case of this stainless steel the surface oxide film is of such a nature as to permit the transition from rough to smooth wear in air, a transition which occurred with carbon steels only when the formation of surface oxide film was retarded by a surrounding atmosphere of hydrogen.



### OXYGEN AND NITROGEN IN ANTIMONY CRYSTALS

Recent investigations have established the fact that single metal crystals are far from having the uniform perfect lattice structure which one might postulate from theoretical considerations. Attempts have been made to correlate this irregularity in the crystal structure with various observed properties. It appears not unreasonable to suppose that if gases were present in a metallic crystal they might be associated to some extent with these irregularities in the crystal lattice structure. In a study of the thermal expansion of single antimony crystals, which has been in progress at the Bureau for some time, variations in the temperature-expansion relationship were observed to occur on annealing the single crystal, and it was suspected that gaseous oxygen or nitrogen in the crystal might be responsible. However, analysis by the vacuum fusion for gases evolved on heating failed to reveal significant amounts of either oxygen or nitrogen. The small traces of gas which were detected could be accounted for on the basis of slight surface oxidation of the antimony.

### RUSSIAN VISITOR STUDIES "GASES IN METALS"

In response to a request from the Embassy of the Union of Soviet Socialist Republics to the U. S. Department of State, permission was granted to a technical representative of the Soviet Institute of Steel to spend several weeks in the metallurgical laboratories of the Bureau. Accordingly, A. M. Samarin, an instructor in metallurgy at the Steel Institute of Moscow, spent the month of December studying the methods recommended and used by the Bureau for determining those constituents of steels which are popularly, though erroneously, termed "gases in steel." Such constituents are related, either in their origin or in their subsequent behavior upon heating, to the ordinary gaseous elements.

### TRAFFIC SIGNALS

The International Commission on Illumination has a committee on traffic signals, and a member of the Bureau's staff is the United States representative on this committee. For the purposes of the international committee an estimate has recently been made of the extent of use of luminous traffic signals in the United States, based

upon statements of manufacturers as to their output. The estimates refer to January 1, 1934.

Reports from manufacturers of signal glasses show the following output:

Green-----	116,700
Amber-----	88,400
Red-----	141,700
Total-----	346,800

The output of red glasses is 21 percent higher than green, which can only be partly accounted for by the replacement of red for amber in the system of certain municipalities.

Reports from manufacturers of signal heads indicate that more than 29,000 intersections in the United States had been equipped. This is a lower limit, as the records are not complete.

Comparison of this figure with the output of signal glasses, without allowance for replacements, indicates an average of approximately 12 signal glasses per intersection. This is a reasonable ratio, as four 1-way 3-color signals would use exactly 12 glasses. A T-intersection using 2 colors would have only 6, while 4-way signals at each of 4 corners using 3 colors (as in Chicago) would involve 48 glasses.

Since the green glass is used in all systems, the number of sets of lenses may be based upon the green, which gives 4 sets of lenses per intersection, the exact number of 4 one-way signal heads.

The data received from manufacturers indicate that about 93 percent of the installations use 3 colors and about 7 percent use only 2 colors. The latter are largely in New York State and the Pacific coast cities. The output of amber glasses is, however, 24 percent less than the green, which would indicate a much larger use of the two-color system.

### RELATION BETWEEN COMPOSITION AND PROPERTIES OF GLASSES

A number of experimental glasses containing soda, alumina, and silica were melted in platinum and analyzed. The index of refraction, density, and thermal expansion of the glasses were determined and graphs prepared to show the changes in the properties mentioned with changes in composition. From these graphs, which have been published in the Journal of Research for February (RP762), it is possible to predict the refractivity, density, or expansivity of any glass in the range of compositions studied.

**LIGHTNING AND THE WASHINGTON MONUMENT**

When the Washington Monument was completed about 50 years ago it was provided with protection against lightning, but not until after it had been struck a number of times and one of the stones cracked.

When the scaffolding was erected to the top of the Monument last year for the purpose of cleaning it, an opportunity was presented for inspecting the lightning-protection equipment. (See Technical News Bulletin No. 212, December 1934.) A member of the Bureau's staff was requested to do this.

The tip of the pyramid which constitutes the top of the Monument is a block of aluminum weighing 100 ounces and nearly 9 inches high. It was surrounded by a gold-plated collar of copper, studded with eight points or terminals. From each corner of the collar a copper rod ran down one edge of the pyramid, and these rods were connected by horizontal strips of copper laid between the courses of stone. Both rods and the horizontal strips carried copper points at intervals. These points were about 3 inches long, tapering from  $\frac{1}{4}$  inch in diameter at the base to about  $\frac{1}{8}$  inch at the outer end. The copper was gold-plated for protection against corrosion, and the pointed end was tipped with a piece of no. 20 platinum wire. There were approximately 200 of these.

The points at the peak of the pyramid showed abundant evidence of having been struck by lightning. Several had been fused at the tip, one carrying a distinct bead of fused copper about  $\frac{1}{4}$  inch in diameter. The heat had corroded the surface somewhat and dissipated the gold, and some of the points had sagged. The tip of the aluminum was roughened and a globule of molten metal had run down one side and frozen.

The copper rods running down the edges of the pyramid were connected at several points through the stone to the interior steel framework supporting the elevator and this framework was loose. No damage had been done by lightning since this installation was made, although the Monument had been frequently struck.

Upon recommendation of the Bureau's engineer, the joints in the rods were repaired and the points at the apex replaced by longer ones which extend higher than the aluminum, so

that they can be expected to receive future strokes. All missing points on the rods and horizontal strips were replaced by gold-plated copper as in the original installation.

A measurement of the resistance between the collar at the apex and the steel framework inside was made after the repairs and found to be less than one-thousandth ohm.

**HINGES FOR REINFORCED CONCRETE STRUCTURES**

The utility of hinges or articulations for reinforced-concrete arches and frames has been recognized for many years. Articulations in these structures fix the position of the line of thrust at definite points in the structure, thereby reducing the uncertainties in analyses of stresses. Stresses caused by movements in the foundations and those produced by shrinkage, plastic flow, rib shortening, and temperature variations can be reduced by the use of hinges, and in the case of the three-hinged arch, almost entirely eliminated.

The type of hinge which was first designed and used by Augustin Mesnager, a French scientist and engineer, appears to be well suited for use in reinforced-concrete structures. These hinges are made by leaving a short gap in the concrete of the member and crossing the reinforcing bars at the gap. Thus the intradosal bars on one side of the gap become the extradosal bars on the other side. This type of hinge is known to offer only a small resistance to rotation or flexure and yet has a considerable resistance to thrust and shear. Before extensive use, however, it seemed desirable to obtain additional experimental data on these properties. At the suggestion of representatives of the Bureau of Yards and Docks, U. S. Navy Department, seven specimens with hinges of the Mesnager type were tested at the National Bureau of Standards.

The specimens, which were designed by Lieutenant Commander Ben Moreell, Bureau of Yards and Docks, resembled a crown hinge with part of the adjacent barrel of a barrel-shaped arch. They were tested under conditions which gave information on both the stiffness and the strength of the hinges when subjected to compressive, shearing, and rotational deformations. The results of the tests indicate that hinges of the Mesnager type may be

designed to provide a wide range in strength and stiffness. A complete report on the investigation will be published in the January-February issue of the Journal of the American Concrete Institute.

#### TENSION TESTS OF FIRE BRICK

The nature of refractory bricks is such as to have discouraged much study of their tensile properties in the past. However, the advent of the Tuckerman optical strain gage has eliminated many of the difficulties, so that strain measurements of materials as brittle as fire-clay brick may now be made accurately. The Bureau has, therefore, undertaken a study of the strength, Young's modulus of elasticity, and maximum strain in tension of 18 commercial brands of fire-clay brick. These brands of brick have been chosen so as to include not only the different processes of manufacture (hand-made, dry press, and stiff mud), but also the range of silica ordinarily found in fire brick.

An apparatus was constructed so as to permit tests to be made both at ordinary and elevated temperatures. The load is gradually applied to the specimens through a simple lever system by means of no. 12 lead shot. Strain measurements are taken from two gages placed opposite one another on the specimen.

Three specimens are machined from each brick, one specimen is cut crosswise and two are cut lengthwise to the brick. The specimens are machined spool shaped and the one cut crosswise to the brick is suitable for a 2-inch gage length and those cut lengthwise are suitable for 3-inch gage lengths. The finished specimens have a circular cross section, 1.50 in.<sup>2</sup> in area.

Some results are available on each of 18 brands of brick. Nine specimens representing three specimens from each of three bricks of one brand have been tested. The range in values for the 18 brands is as follows: Modulus of elasticity from 209,000 to 7,600,000 lb/in.<sup>2</sup>, the tensile strength from 40 to 920 lb/in.<sup>2</sup>, and the strain from 0.0052 to 0.0316 percent. Comparing the values obtained for the crosswise and the lengthwise specimens shows that the modulus of elasticity was greater for the crosswise specimens in 11 brands, less in 6, and equal in 1. The strength of the crosswise specimens was less than the lengthwise specimens in 16 brands. Crosswise specimens from a single brick were found to be as much as 65

percent higher in modulus of elasticity in comparison with lengthwise specimens. The following values obtained on two brands show the possible uniformity and nonuniformity of tensile properties which may occur. First brand, modulus of elasticity and strength lengthwise 1,225,000 and 300 lb/in.<sup>2</sup>, respectively; modulus of elasticity and strength crosswise 1,220,000 and 260 lb/in.<sup>2</sup>, respectively. Second brand, modulus of elasticity and strength lengthwise, 1,530,000 and 355 lb/in.<sup>2</sup>, respectively; crosswise 2,530,000 and 350 lb/in.<sup>2</sup>, respectively.

#### CALIBRATION OF WAGNER TURBIDIMETER

Twenty-seven laboratories cooperated with the cement reference laboratory at the Bureau in a study of a suggested method of calibration of the Wagner turbidimeter, an instrument now used by many laboratories in determining the fineness of portland cement. It was believed that the new method would bring about better agreement among laboratories than was secured through the earlier method.

Four samples of cement were used. One sample was selected as the standard for calibration, its specific surface and no. 325 sieve values being given. The three remaining samples were unknowns to test the efficiency of the proposed method. Results by the old method were reported by 24 laboratories, while 27 reported results using the new method. The range in results by the new method was much smaller than existed in the results by the older method. Also, by the new method the standard deviation and the probable error were less than one-half of the respective values for the old method. The new calibration method forms part of the recently adopted ASTM tentative method of test for fineness of portland cement by means of the Wagner turbidimeter, C115-34T.

It was found that the specific surface of the standard sample decreased rapidly after exposure to the air. Therefore, the sample prepared by the Bureau for this calibration, Standard Sample no. 114, is now "glass-sealed" in small vials. Each sample consists of three vials, each vial containing sufficient cement for three calibrations, including the no. 325 sieve test by the wet method.

There has been some occasional discussion as to the probable magnitude of the error incident to the use of



the no. 325 sieve in the turbidimeter determination. (One gram is tested on a small sieve by the wash method.)

This question is answered by the following study of the values reported by the 27 laboratories above mentioned.

Nature of data	Sample number		
	23678	23680	23934
Average amount passing.....	% 88.4	% 94.9	% 89.3
Standard deviation.....	0.8	0.5	0.9
Probable error.....	0.6	0.3	0.6
Surface area equivalent to the above probable error in sieving.....	11 cm <sup>2</sup> /g	9 cm <sup>2</sup> /g	13 cm <sup>2</sup> /g

#### STANDARDS FOR GAS SERVICE

A revision of the Bureau's circular on "Standards for Gas Service" was released last month. The purpose of the publication is to supply the technical information needed by anyone concerned with the basis of charging for gas or with the conditions which will result in satisfactory service.

With the exception of coal, city gas is the principal source of heat energy for use in American homes, and it is as a supply of energy rather than as a material that gas is discussed in the circular. It is of no concern to the user how many cubic feet of gas he can buy for a dollar; the only things that matter are the amount of energy received and the maintenance of conditions which will make it easy to control the energy in use. Fixing the price of gas per cubic foot results in many complications and often in unsatisfactory or wasteful conditions which can be avoided when the price per unit of energy is established instead, as it is in Great Britain and Japan, and in the State of Colorado and the city of Chicago. This is particularly important in the case of natural gas, for which a minimum standard of heating value, such as is usually established for manufactured gas, is unsuitable. Natural gas at present constitutes the major portion of the Nation's supply, and the conditions under which it is produced, distributed, and sold deserve much more attention from the public than they have received.

In addition to the heating value of gas, the circular discusses the maintenance of satisfactory pressures, the composition of the gas, the adjustment of appliances, the accuracy and testing of meters and the adjustment of bills when meters are found in error, and the extension of the distributing system to supply new customers. Recom-

mendations are made in relation to each of these topics and the reasons for them are fully explained.

A summary is given of all existing State regulations relating to gas, so arranged that it is easy to compare the rules on any subject. Another summary indicates what gas companies themselves regard as good practice. There is also a description of the properties, sources, and methods of manufacture of the numerous kinds of gas which go to make up city supplies.

The circular, C405, can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 20 cents a copy.

#### SPECIFIC VOLUME OF RUBBER-SULPHUR COMPOUNDS

RP760 in the February number of the Journal of Research describes an investigation recently completed on the effect of pressure and temperature on the specific volume of rubber-sulphur compounds. The values of the specific volumes were obtained from measurements of the changes in lengths of rubber rods as the various pressures were applied. The changes in length were obtained by observing, with a microscope, a scale which had been fastened to the end of the rod when the other end was rigidly held. The specific volume was found to be a function of the pressure, temperature, and sulphur content. It decreased with pressure and sulphur content, and increased with temperature. The compressibility of the soft-rubber specimens was found to be about three times that of the hard-rubber specimens. The volume thermal expansivity decreased with both the pressure and sulphur content. The soft-rubber specimens had a volume expansivity about three times that of the hard-rubber specimens.

**DETERIORATION OF VEGETABLE-TANNED LEATHER BY SULPHURIC ACID**

The production of commercial leather requires the use of many materials in addition to skins and tanning agents. One of these materials, sulphuric acid, has long been used for bleaching purposes in connection with the manufacture of vegetable-tanned leather for shoe soles, belting, harness, upholstery, and in the fabrication of bags, cases, and miscellaneous leather goods. Experience has demonstrated that leather will deteriorate on aging if too much acid is present. For this reason the producers, by controlling the manufacturing processes, and the users, through specifications, have constantly sought to keep the mineral acidity of leather within limits considered safe.

Researches have been in progress at the Bureau for a number of years, to determine the behavior of leathers containing sulphuric acid with the object of establishing an accurate limit on the amount of acid which can be present without causing serious deterioration within a reasonable time. It was found that the safe amount varied with the character of the leather from approximately 0.3 to 1.8 percent. This situation made it difficult to establish a single limit for permissible acid content unless the minimum amount found to cause deterioration of any leather were accepted. This was obviously not desirable since some leathers will stand more acid than others, and moreover, a number of new sulphur-containing materials used in making leather are, in part, determined as acid by the usual method of chemical examination. These materials, such as sulphonated oils, sulphited extracts, and synthetic products, are not considered harmful to the life of leather.

In a recent investigation described in RP761 in the February Journal of Research, attention was given to determining the activity of the acid in the leather rather than the amount of acid present. This effective acidity is represented by the pH value of the leather and was determined with special equipment designed for the purpose. It was found that in the case of all the leathers studied, deterioration bore a more definite relation to pH, effective acidity, than to actual acid present. In fact, all leathers started to deteriorate at or near a pH of 3. It is believed that this new means of determining acidity affords the user of leather better insurance

against material containing a harmful amount of acid than has existed heretofore.

It is conceivable that some of the materials used in making leather may have an influence on the deterioration of the leather by acid. Researches have been completed to show the influence of one such material, namely, magnesium sulphate. This salt is largely used in the finishing of sole leather. It is hygroscopic and tends to prevent the leather from becoming too harsh and dry through lack of moisture. The addition of this salt to leather has the immediate effect of decreasing the effective acidity. The results of tests show that, of two leathers containing the same amount of acid, the one containing magnesium sulphate will deteriorate less. However, on the basis of effective acidity, there is no difference in the deterioration of the leathers. The experiments show that a leather, which has sufficient acid present to cause serious loss in strength in 2 years, may possibly be protected from this deterioration by the addition of magnesium sulphate. Thus, it will be seen that the limited use of magnesium sulphate in leather may be beneficial.

**COMBINING WEIGHT OF COLLAGEN**

In an investigation described in RP765 in the February number of the Journal of Research, the adsorption of hydrochloric acid by collagen was determined in solutions varying in acid concentration from 0 to 1.7 molal. The solutions were nearly or completely saturated with sodium chloride. The high concentration of salt was used to repress the swelling of the collagen, and to provide a reference substance for the measurement of the adsorption. The quantity of acid reacting with the collagen was found to vary continuously with the concentration of acid. At concentrations higher than molal there was enough hydrolysis of the collagen to interfere with the measurements of adsorption.

The nature of the relation between the concentration and the quantity of acid combined indicates that at least three types of compounds are formed by the collagen and the hydrochloric acid. At low concentrations, the combining weight of the collagen is about 1,000. As one gram of collagen contains approximately 12.7 milligram atoms of nitrogen, the fraction of the total nitrogen which is strongly basic is 0.08. Then, since the nitrogen atoms in collagen occur in sets of thirty-eight

or a multiple thereof, the number of strongly basic nitrogen atoms in a unit of thirty-eight is the integer approximated by  $30 \times 0.08$ , or three.

The equivalent weight of collagen, defined as the weight of collagen which reacts with one equivalent of acid at an indefinitely high concentration, is indeterminate under the conditions of this experiment. So many types of nitrogen-containing groups are reacting with the acid that not even an approximate value of the true equivalent weight can be selected.

**NEW AND REVISED PUBLICATIONS  
ISSUED DURING JANUARY 1935**

**Journal of Research<sup>1</sup>**

Journal of Research of the National Bureau of Standards, vol. 14, no. 1, January 1935 (RP nos. 753 to 758, inclusive). Price 25 cents. Obtainable by subscription.

**Research Papers<sup>1</sup>**

[Reprints from the September, October, November, and December 1934 Journal of Research]

RP710. Interference measurements in the spectra of noble gases. W. F. Meggers and C. J. Humphreys. Price 5 cents.

RP713. Heats of combustion of rubber and of rubber-sulphur compounds. R. S. Jessup and A. D. Cummings. Price 5 cents.

RP716. Coil arrangements for producing a uniform magnetic field. F. K. Harris. Price 5 cents.

RP717. Forms of rubber as indicated by temperature-volume relationship. N. Bekkedahl. Price 5 cents.

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RP739. A temperature-control box for saturated standard cells. E. F. Mueller and H. F. Stinson. Price 5 cents.

RP741. Compression tests of structural steel at elevated temperatures. P. D. Sale. Price 5 cents.

RP742. Effect of cold-rolling on the indentation hardness of copper. J. G. Thompson. Price 5 cents.

RP752. An analysis of continuous records of field intensity at broadcast frequencies. K. A. Norton, S. S. Kirby, and G. H. Lester. Price 5 cents.

**Circulars<sup>1</sup>**

Circular of the National Bureau of Standards C405. Standards for gas service. Price 20 cents.

**Handbook<sup>1</sup>**

National Bureau of Standards Handbook H19, Manual of fire-loss prevention of the Federal Fire Council. Price 20 cents.

**Simplified Practice Recommendations<sup>1</sup>**

R108-34. Dental hypodermic needles. Price 5 cents.

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Commercial Standards<sup>1</sup>

CS50-34. Binders board for bookbinding and other purposes. Price 5 cents.

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## LETTER CIRCULARS

It is the intent of the Bureau to distribute single copies of these Letter Circulars on request only to those parties having special interest in the individual Letter Circular. Economy necessitates limitation in the number of copies issued. It is not the intent to supply parties with a copy of each Letter Circular issued during the month. Letter Circulars are necessarily of a temporary nature designed to answer numerous inquiries on a given subject. Requests should be addressed to the National Bureau of Standards.

Supplement no. 2 to LC256a (revised). Sources of supply of commodities covered by Federal specifications.

LC277a (revised). Sources of supply of commodities covered by commercial standards.

LC287 (revised). List of published material relating to home building and maintenance.

LC433. The corrosivity of soils.

LC434. Soil corrosion surveys.

LC435. Protective coatings for underground piping systems.

## REPORTS OF NATIONAL HYDRAULIC LABORATORY

Current hydraulic laboratory research in the United States. Report no. III-1 (January 1, 1935). Mimeographed. Free on application to National Bureau of Standards, Washington, D. C.

OUTSIDE PUBLICATIONS<sup>2</sup>

Dental research at the National Bureau of Standards in relation to

orthodontia. G. C. Paffenbarger and W. T. Sweeney. *Int. J. Orthodontia and Dentistry for Children* (St. Louis, Mo.), **30**, 1166 (December 1934).

Crystalline  $\beta$ -glucoheptose and its mutarotation. H. S. Isbell. *J. Am. Chem. Soc.* (Mills Building, Washington, D. C.), **56**, 2789 (December 1934).

Opacity standards. D. B. Judd. *Paper Trade J.* (10 East 39th St., New York, N. Y.), **100**, TS28 (1935).

A Maxwell triangle yielding uniform chromaticity scales. D. B. Judd. *J. Optical Soc. Am.* (Cornell University, Ithaca, N. Y.), **25**, 24 (1935).

Ultraviolet transmission changes in glass as a function of the radiation stimulus. W. W. Coblenz and R. Stair. *Proc. Nat. Acad. Sci.* (Washington, D. C.), **20**, 630 (December 1934).

The absorption of moisture by aeronautical textiles. G. M. Kline. *Am. Dyestuff Reporter* (90 William St., New York, N. Y.), **24**, 4 (January 14, 1935).

The deterioration of vegetable-tanned leather by oxalic acid. R. C. Bowker and J. R. Kanagy. *J. Am. Leather Chem. Assn.* (Ridgeway, Pa.), **30**, 26 (January 1935).

Observations on effect of surface finish on the initial corrosion of steel under water, with discussion. L. J. Waldron and E. C. Groesbeck. *Proc. Am. Soc. Testing Materials* (260 S. Broad St., Philadelphia, Pa.), **34**, part II, 123 (1934).

Note on the frictional resistance of steel and brass in shrink fits, with discussion. W. H. Swanger. *Proc. Am. Soc. Testing Materials* (260 S. Broad St., Philadelphia, Pa.), **34**, part II, 165 (1934).

Reports of joint committee on investigation of effect of phosphorus and sulphur in steel. H. S. Rawdon. *Proc. Am. Soc. Testing Materials* (260 S. Broad St., Philadelphia, Pa.); Effect of sulphur in forging steel, **34**, part I, 87 (1934); Effect of added phosphorus on low-carbon steel, **34**, part I, 113 (1934).

A simple apparatus for determining heat of hydration of portland cement. Wm. Lerch. *Paper no. 27 of the Portland Cement Association Fellowship* (National Bureau of Standards, Washington, D. C.) (October 1934).

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